Improving Assessment of Entrainment Impacts Through Models of Coastal and Estuarine Withdrawal Zones

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The Issue

Approximately 45 percent of California's generation capacity is provided by facilities that use once-through cooling technology and are located along the state's coast and estuaries. Once-through cooling requires the withdrawal of significant amounts of water (~17 billion gallons per day) from a waterbody, and that water is passed by the condenser and discharged back into a waterbody. Although some of these facilities have been operating since the 1950s, scientific understanding of the ecological effects attributable to once-through cooling is quite limited. The impacts of cooling water withdrawals are characterizedq as *entrainment*, where small aquatic organisms are carried by the cooling water into the power plant and killed by heat, and as *impingement*, where the cooling water intake traps larger organisms against the intake screens. Discharge of cooling water heated to levels significantly above temperatures of the receiving waterbody can also alter aquatic ecosystems.

Coastal waters near the AES power plant in Huntington Beach, California. The power plant is near the top of the photo.

One of models used to determine entrainment impacts on the source population is the Empirical Transport Model (ETM), but the operational assessments of larvae losses through entrainment based on the ETM do not adequately account for the effects of water motion. In those estimates, the spatial resolution of the locations from which larvae are entrained is limited, and seasonal variability is not captured. Further, the assessments may over- or under-estimate the entrainment impact.

Project Description

To reduce these inadequacies, this research project is analyzing the extended *withdrawal zone* of power plant intakes—that is, the area from which water and larvae, spores, and weakly swimming juveniles are drawn into a power plant. The analysis will account for vertical locations of larvae, seasonal variations in current, and mixing effects. The researchers will investigate this issue through a combination of modeling and data analysis.

The study includes development of a generic model that will track the movement of larvae in coastal waters; accounting for distance offshore from the intake, alongshore and cross-shore flows, and time scales according to planktonic larval duration of particular species. The shape of the intake withdrawal zone is expected to be as shown in Figure 1, and model uncertainty will be determined.

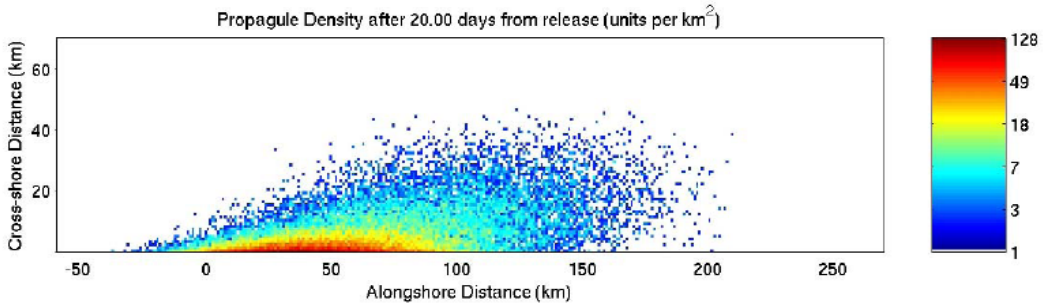

Figure 1. *Model of 20-day larval dispersal. Particles are released at the shore at 0km (40,000 particles released). Flow has alongshore velocity of 0.1 m/s offshore, with linear cross-shore shear over innermost 10km and 0.01 m/s alongshore velocity at the shoreline. Diffusive effects are represented by random alongshore velocity fluctuations with maximum of 0.2 m/s and cross-shore fluctuations with maximum of 0.1 m/s, both decreasing to zero at shoreline.*

The research team will obtain and analyze available data on current velocities and plankton concentrations to improve understanding of flow features necessary to modeling efforts and to obtain direct, data-based entrainment estimates. The data will then be used for a detailed assessment of the flow patterns and withdrawal zone for the AES Huntington Beach Generating Station, where the intake is located in open coastal waters. The generic model will be evaluated for the Huntington Beach plant and the value of the model will be assessed as more data is used in addressing the entrainment problem. Further evaluations of Morro Bay and the head of San Diego Bay will provide further points of reference with which to compare the generic model.

A cumulative impact model will also be developed to model interactions of multiple power plants. This model will assess the effect of multiple power plants that rely on once-through cooling on larval entrainment. The generic model developed for a single power plant will be applied to multiple plants, to assess the cumulative entrainment effects of multiple operations.

The researchers will take advantage of emerging operational models and observations of coastal circulation. Hourly radar maps of surface currents will be available for most intake locations, as provided by the Coastal Ocean Observing Systems (COOS). The value of these data and large-scale circulation models will be explored, as applied to entrainment modeling. Throughout the two-year project, the investigation will collaborate with other WISER-funded investigators, the California Energy Commission, and power plant consultants in order to integrate results with other studies. This procedure will help integrate knowledge of larval spawning and distributions, and will ultimately improve protocols for assessing entrainment and identify management actions that could mitigate entrainment impacts.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Improving the environmental costs/risk of California's electricity.** Improving understanding of the entrainment impacts of once-through cooling on California's aquatic biota will help engineers develop better intake technologies and help the state's decision makers create policies to ensure the health of the fish and other organisms in the water bodies that supply cooling water. Development of a

cumulative impact model will help decision makers by supplying information on effects from multiple power plants.

The project also meets the PIER's goals to conduct research and development activities that will advance science or technology not adequately addressed by the competitive and regulated markets that evaluate and resolve environmental effects of energy delivery in California and provide clearly identifiable benefits to California's ratepayers.

Final Report

PIER-EA staff intend to post all the final project reports on the Energy Commission website as the research is completed (fall 2008 for the program final report) and will list the website links here. All reports are also posted at the Water Intake Structure Environmental Research (WISER) website, at http://ecomorphology.mlml.calstate.edu/WISER.html.

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